UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Northwest Fisheries Science Center
Fish Ecology Division
2725 Montlake Boulevard East
Seattle, WA 98112-2097
(206) 860-3270

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MEMORANDUM FOR: F/NWR5 - Bruce Suzumoto

FROM: F/NWC3 - Richard W. Zabel

SUBJECT: Preliminary survival estimates for the passage of
                 spring-migrating juvenile salmonids through Snake
                 and Columbia River dams and reservoirs, 2013

This memorandum summarizes conditions in the Snake and Columbia
Rivers and preliminary estimates of survival of PIT-tagged
juvenile salmonids passing through reservoirs and dams during the
2013 spring outmigration. We also provide preliminary estimates
of the proportion of Snake River smolts that were transported
from Snake River dams in 2013. Our complete detailed analyses
and report for the spring migration will be available by the end
of the year. As in past years, changes in the database between
the time of our annual summer memo and the publication of our
final report may result in differences of up to 3 or 4% in
estimated survival values.

Summary of Research

For survival studies funded by BPA in 2013, NOAA Fisheries PIT
tagged approximately 17,380 river-run hatchery steelhead, 7,457
wild steelhead, and 11,773 wild yearling Chinook salmon for
release into the tailrace of Lower Granite Dam.

Survival estimates provided in this memorandum are derived from
PIT-tag data from fish PIT tagged by or for NOAA Fisheries, as
described above, along with fish PIT tagged by others within the
Columbia River Basin.

For yearling Chinook salmon from Snake River Basin hatcheries,
estimated survival to Lower Granite Dam tailrace has been
relatively stable since 1998 (Figure 1, Table 1). Mean estimated
survival was a composite of production releases from hatcheries

Dworshak, Kooskia, Lookingglass/Imnaha Weir, Rapid River, McCall/Knox Bridge, Pahsimeroi, and Sawtooth and has ranged between 54.9 and 69.7% since 1998. Mean estimated survival to Lower Granite Dam tailrace for the index hatchery release groups in 2013 was 66.7%.

Estimated survival for Snake River yearling Chinook salmon (hatchery and wild combined) in 2013 was above average (1993-2013) in all reaches except the Snake River Trap to Lower Granite Dam tailrace reach and the Lower Granite Dam tailrace to Little Goose tailrace reach (Tables 2 and 4, Figures 2 and 3). Mean estimated survival for yearling Chinook salmon from Lower Granite Dam tailrace to McNary Dam tailrace in 2013 was 78.1% (95% CI: 74.9, 81.2%). Mean estimated survival in 2013 from McNary Dam tailrace to Bonneville Dam tailrace was 79.2% (95% CI: 65.3, 93.1%). Mean estimated survival for yearling Chinook salmon from Lower Granite Dam tailrace to Bonneville Dam tailrace was 61.9% (95% CI: 50.7, 73.0%). Estimated survival for the Lower Granite project (head of reservoir to tailrace) was 84.5%, based on fish PIT tagged at and released from the Snake River trap. The combined yearling Chinook salmon survival estimate from the trap to the Bonneville Dam tailrace in 2013 was 52.3% (95% CI: 42.1, 62.4%).

For Snake River steelhead (hatchery and wild combined), mean estimated survival in 2013 was above the average (1993-2013) in every reach except for the Lower Monumental Dam tailrace to McNary Dam tailrace reach and the McNary Dam tailrace to John Day Dam tailrace reach (Tables 3 and 5, Figures 2 and 3). Mean estimated survival for steelhead from Lower Granite Dam tailrace to McNary Dam tailrace in 2013 was 64.5% (95% CI: 59.4, 69.6%). Mean estimated survival from McNary Dam tailrace to Bonneville Dam tailrace was 79.8% (95% CI: 57.8, 100%). Mean estimated survival from Lower Granite Dam tailrace to Bonneville Dam tailrace was 51.5% (95% CI: 36.7, 66.2%). Estimated survival for the Lower Granite project (head of reservoir to tailrace) was 97.3%, based on fish PIT tagged at and released from the Snake River trap. The combined steelhead survival estimate from the trap to the Bonneville Dam tailrace in 2013 was 50.1% (95% CI: 35.4, 64.8%).

For PIT-tagged hatchery yearling Chinook salmon originating from the upper Columbia River in 2013, estimated survival from McNary Dam tailrace to Bonneville Dam tailrace was 100.0% (95% CI: 85.0, 100.0%; see Table 6).

For PIT-tagged hatchery steelhead originating from the upper Columbia River in 2013, estimated survival from McNary Dam tailrace to Bonneville Dam tailrace was 93.2% (95% CI: 75.7, 100.0%; Table 6). For fish released from upper Columbia River hatcheries, we cannot estimate survival in reaches upstream from McNary Dam (other than the overall reach from release to McNary Dam tailrace) because of limited PIT-tag detection capabilities at Mid-Columbia River PUD dams.

Estimated survival in 2013 of Snake River sockeye salmon (hatchery and wild combined) from the tailrace of Lower Granite Dam to the tailrace of Bonneville Dam was 53.6% (95% CI: 42.1%, 68.2%; Table 7). Estimated survival in 2013 of Columbia River sockeye salmon (hatchery and wild combined) from the tailrace of Rock Island Dam to the tailrace of Bonneville Dam was 48.7% (95% CI: 26.5%, 89.5%; Table 7).

Our preliminary estimates of the proportion transported of non-tagged wild and hatchery spring-summer Chinook salmon smolts are 36.1% and 31.0%, respectively. For steelhead, the estimates are 40.0% and 35.5% for wild and hatchery smolts, respectively. These estimates represent the proportion of smolts that arrived at Lower Granite Dam that were subsequently transported, either from Lower Granite Dam or from one of the downstream collector dams.

Discussion

For Snake River yearling Chinook salmon in 2013, estimated survival from Lower Granite Dam tailrace to Bonneville Dam tailrace was 61.9%, which was the third highest we have observed in the 1999-2013 time series (higher only in 2006 and 2012). However, an unusually low estimated survival of 84.5% from the Snake River Trap to Lower Granite Dam tailrace resulted in an estimated survival through the hydropower system (Snake River trap to Bonneville tailrace) of 52.3%. This hydropower system estimate was lower than the 2012 estimate of 58.8% but not significantly different ($P = 0.32$; Table 4). Estimated survival for yearling Chinook salmon between Lower Granite and McNary Dams in 2013 was 3.9% higher than the long-term average (78.1% vs. 74.2%). Between McNary and Bonneville Dams, estimated survival in 2013 was 8.3% higher than the long-term average (79.2% vs. 70.9%). Chinook survival through the hydropower system has remained relatively stable since 1999 with the exception of lower estimates in 2001 and 2004.

For steelhead in 2013, estimated survival through the hydropower system was 50.1%, which was above the long-term average of 43.2% but also the lowest estimate since 2008 (Table 5). Despite being 9.8% lower than the estimate from 2012 of 59.8%, the two estimates were not significantly different due to the high uncertainty of the 2012 estimate ($P = 0.54$; Table 5). Lower than average estimated mean survival from McNary Dam Tailrace to John Day Dam tailrace (79.9% vs. 80.7% average) and from Lower Monumental Dam tailrace to McNary Dam tailrace (73.9% vs. 75.5% average) contributed to an estimated survival through the hydropower system for steelhead in 2013 which was relatively low in comparison to that of recent years. Survival estimates for weekly release groups from Lower Granite Dam indicated that survival for steelhead decreased through the last few weeks of the season from Lower Granite Dam tailrace to McNary Dam tailrace. This pattern has been observed in previous years and could be caused by increased predation and increasing temperatures during that period.

Mean flow volume at Little Goose Dam in 2013 during the main migration period (1 April – 15 June) was 67.8 kcfs, which was below the long-term (1993-2013) mean of 92.0 kcfs, and fifth lowest among mean flows over the past 21 years. Daily flow volumes were below average for much of the season, but were above average from 9-16 May as a pulse of flow moved through (Figure 4). Mean water temperature at Little Goose Dam in 2013 during the migration period was 11.3 °C, which is slightly above the long-term mean of 11.1 °C. Daily water temperatures fluctuated around the long term daily averages, with excursions above average occurring during 4-12 April, 2-16 May, and 3-15 June (Figure 4).

Mean spill volume at the Snake River dams during the 2013 migration was 22.3 kcfs, which was a little below the long-term mean of 25.9 kcfs. Daily spill volumes remained near the long-term daily averages until going below average during 15 May through 15 June (Figure 5). Mean spill as a percentage of flow at the Snake River dams during the 2013 migration was 33.5%, which was above the long-term mean of 25.1%. Daily average spill percentages in 2013 were above the long-term daily averages for the entire migration except for the period 9-18 May, which corresponded to the period of increased flow. In general, river conditions during the 2013 spring migration could be categorized as low flow with moderately high temperatures at times and with above average spill percentages. These conditions are similar to those that occurred in 2007 and 2010.

Estimated percentages of yearling Chinook salmon and steelhead transported from Snake River dams in 2013 were greater than the record low percentages estimated in 2012. The increase was due to a combination of an earlier start date of transportation and a later arrival of smolts at Lower Granite Dam in 2013. Collection for transportation in 2013 began on 27 April at Lower Granite Dam, 3 May at Little Goose Dam, and 7 May at Lower Monumental Dam. In comparison, the transportation start date at Lower Granite Dam in 2012 was 2 May; five days later than in 2013. However, transportation start dates at the other two collector dams in 2013 were actually one day later than those in 2012. When smolt transportation started at Lower Granite Dam in 2013, approximately 26% of Chinook and 26% of steelhead smolts had already passed the dam. Smolt passage increased rapidly with increasing flow in early May (Figures 4 and 6), and 90% passage at Lower Granite Dam occurred by approximately 14 May for Chinook and 17 May for steelhead. Throughout the migration season, relatively high spill percentages in combination with continuous operation of surface bypass collectors at each of the collector dams on the Snake River resulted in low proportions of fish entering juvenile bypass systems. Low flow conditions in 2013 may have increased spillway passage because lower water velocities allow fish more time to react to conditions and may increase the attractiveness of surface bypass collectors. During the period of general transportation in 2013, we estimate that approximately 46% of Chinook and 51% of steelhead smolts that arrived at Lower Granite Dam were transported from one of the collector dams. These percentages are actually lower than those estimated for 2012 (59% Chinook and 62% steelhead). Despite the increase over 2012 estimates, the transport percentages for 2013 are still among the lowest estimated over the period for which we have estimates (1993-2013).

cc: F/NWC3 – Faulkner
     F/NWC3 – Marsh
     F/NWC3 – Smith
     F/NWC3 – Widener
     F/NWC3 – Zabel

Table 1.   Mean estimated survival and standard error (s.e.) for yearling **Chinook** salmon released at Snake River Basin and Upper Columbia River hatcheries to Lower Granite Dam tailrace (LGR) and McNary Dam tailrace (MCN), 2011 through 2013.

Hatchery	2011		2012		2013[a]	
	Survival to LGR (s.e.)	Survival to MCN (s.e.)	Survival to LGR (s.e.)	Survival to MCN (s.e.)	Survival to LGR (s.e.)	Survival to MCN (s.e.)
Dworshak	0.722 (0.006)	0.511 (0.010)	0.743 (0.008)	0.642 (0.013)	0.794 (0.015)	0.661 (0.014)
Kooskia	0.729 (0.014)	0.542 (0.029)	0.652 (0.013)	0.409 (0.018)	0.609 (0.026)	0.487 (0.022)
Lookingglass (Catherine Cr.)	0.300 (0.007)	0.228 (0.020)	0.345 (0.007)	0.286 (0.015)	0.220 (0.007)	0.210 (0.018)
Lookingglass (Grande Ronde)	0.434 (0.019)	0.386 (0.097)	0.453 (0.018)	0.350 (0.033)	0.382 (0.024)	0.438 (0.097)
Lookingglass (Imnaha River)	0.572 (0.009)	0.424 (0.025)	0.689 (0.009)	0.568 (0.017)	0.703 (0.019)	0.633 (0.026)
Lookingglass (Lostine River)	0.490 (0.022)	0.409 (0.097)	0.665 (0.017)	0.546 (0.035)	0.604 (0.014)	0.585 (0.050)
McCall (Johnson Cr.)	0.264 (0.015)	0.222 (0.053)	0.357 (0.016)	0.370 (0.049)	0.554 (0.026)	0.469 (0.064)
McCall (Knox Bridge)	0.631 (0.007)	0.469 (0.018)	0.571 (0.006)	0.561 (0.012)	0.656 (0.011)	0.605 (0.018)
Pahsimeroi	0.498 (0.005)	0.371 (0.010)	0.581 (0.006)	0.438 (0.012)	0.606 (0.016)	0.570 (0.021)
Rapid River	0.766 (0.006)	0.533 (0.016)	0.718 (0.014)	0.634 (0.030)	0.735 (0.011)	0.653 (0.021)
Sawtooth	0.521 (0.007)	0.370 (0.024)	0.473 (0.008)	0.398 (0.016)	0.564 (0.011)	0.575 (0.033)
Entiat	---	0.536 (0.041)	---	0.681 (0.042)	---	0.627 (0.049)
Winthrop	---	0.529 (0.051)	---	0.535 (0.036)	---	0.571 (0.034)
Leavenworth	---	0.432 (0.022)	---	0.589 (0.020)	---	0.616 (0.026)

a. Estimates are preliminary and subject to change.

Table 2. Annual weighted means of survival probability estimates for yearling **Chinook** salmon (hatchery and wild combined), 1993–2013. Standard errors in parentheses. Reaches with asterisks comprise two dams and reservoirs (i.e., two projects); the following column gives the square root (i.e., geometric mean) of the two–project estimate to facilitate comparison with other single–project estimates. Simple arithmetic means across all years are given. Abbreviations: Trap–Snake River Trap; LGR–Lower Granite Dam; LGO–Little Goose Dam; LMO–Lower Monumental Dam; IHR–Ice Harbor Dam; MCN–McNary Dam; JDA–John Day Dam; TDA–The Dalles Dam; BON–Bonneville Dam.

Year	Trap–LGR	LGR–LGO	LGO–LMO	LMO–MCN*	LMO–IHR IHR–MCN	MCN–JDA	JDA–BON*	JDA–TDA TDA–BON
1993	0.828 (0.013)	0.854 (0.012)						
1994	0.935 (0.023)	0.830 (0.009)	0.847 (0.010)					
1995	0.905 (0.010)	0.882 (0.004)	0.925 (0.008)	0.876 (0.038)	0.936			
1996	0.977 (0.025)	0.926 (0.006)	0.929 (0.011)	0.756 (0.033)	0.870			
1997	NA	0.942 (0.018)	0.894 (0.042)	0.798 (0.091)	0.893			
1998	0.925 (0.009)	0.991 (0.006)	0.853 (0.009)	0.915 (0.011)	0.957	0.822 (0.033)		
1999	0.940 (0.009)	0.949 (0.002)	0.925 (0.004)	0.904 (0.007)	0.951	0.853 (0.027)	0.814 (0.065)	0.902
2000	0.929 (0.014)	0.938 (0.006)	0.887 (0.009)	0.928 (0.016)	0.963	0.898 (0.054)	0.684 (0.128)	0.827
2001	0.954 (0.015)	0.945 (0.004)	0.830 (0.006)	0.708 (0.007)	0.841	0.758 (0.024)	0.645 (0.034)	0.803
2002	0.953 (0.022)	0.949 (0.006)	0.980 (0.008)	0.837 (0.013)	0.915	0.907 (0.014)	0.840 (0.079)	0.917
2003	0.993 (0.023)	0.946 (0.005)	0.916 (0.011)	0.904 (0.017)	0.951	0.893 (0.017)	0.818 (0.036)	0.904
2004	0.893 (0.009)	0.923 (0.004)	0.875 (0.012)	0.818 (0.018)	0.904	0.809 (0.028)	0.735 (0.092)	0.857
2005	0.919 (0.015)	0.919 (0.003)	0.886 (0.006)	0.903 (0.010)	0.950	0.772 (0.029)	1.028 (0.132)	1.014
2006	0.952 (0.011)	0.923 (0.003)	0.934 (0.004)	0.887 (0.008)	0.942	0.881 (0.020)	0.944 (0.030	0.972
2007	0.943 (0.028)	0.938 (0.006)	0.957 (0.010)	0.876 (0.012)	0.936	0.920 (0.016)	0.824 (0.043)	0.908
2008	0.992 (0.018)	0.939 (0.006)	0.950 (0.011)	0.878 (0.016)	0.937	1.073 (0.058)	0.558 (0.082)	0.750
2009	0.958 (0.010)	0.940 (0.006)	0.982 (0.009)	0.855 (0.011)	0.925	0.866 (0.042)	0.821 (0.043)	0.906
2010	0.968 (0.040)	0.962 (0.011)	0.973 (0.019)	0.851 (0.017)	0.922	0.947 (0.021)	0.780 (0.039)	0.883
2011	0.943 (0.009)	0.919 (0.007)	0.966 (0.008)	0.845 (0.012)	0.919	0.893 (0.026)	0.766 (0.080)	0.875
2012	0.928 (0.012)	0.907 (0.009)	0.939 (0.010)	0.937 (0.016)	0.968	0.915 (0.023)	0.866 (0.058)	0.931
2013[a]	0.845 (0.031)	0.922 (0.012)	0.983 (0.014)	0.904 (0.022)	0.951	0.938 (0.058)	0.827 (0.043)	0.909
Mean	**0.934 (0.009)**	**0.926 (0.008)**	**0.922 (0.011)**	**0.862 (0.014)**	**0.928**	**0.884 (0.019)**	**0.797 (0.029)**	**0.890**

a. Estimates are preliminary and subject to change.

Table 3. Annual weighted means of survival probability estimates for **steelhead** (hatchery and wild combined), 1993–2013. Standard errors in parentheses. Reaches with asterisks comprise two dams and reservoirs (i.e., two projects); the following column gives the square root (i.e., geometric mean) of the two–project estimate to facilitate comparison with other single–project estimates. Simple arithmetic means across all years are given. Abbreviations: Trap–Snake River Trap; LGR–Lower Granite Dam; LGO–Little Goose Dam; LMO–Lower Monumental Dam; IHR–Ice Harbor Dam; MCN–McNary Dam; JDA–John Day Dam; TDA–The Dalles Dam; BON–Bonneville Dam.

Year	Trap–LGR	LGR–LGO	LGO–LMO	LMO–MCN*	LMO–IHR IHR–MCN	MCN–JDA	JDA–BON*	JDA–TDA TDA–BON
1993	0.905 (0.006)							
1994	NA	0.844 (0.011)	0.892 (0.011)					
1995	0.945 (0.008)	0.899 (0.005)	0.962 (0.011)	0.858 (0.076)	0.926			
1996	0.951 (0.015)	0.938 (0.008)	0.951 (0.014)	0.791 (0.052)	0.889			
1997	0.964 (0.015)	0.966 (0.006)	0.902 (0.020)	0.834 (0.065)	0.913			
1998	0.924 (0.009)	0.930 (0.004)	0.889 (0.006)	0.797 (0.018)	0.893	0.831 (0.031)	0.935 (0.103)	0.967
1999	0.908 (0.011)	0.926 (0.004)	0.915 (0.006)	0.833 (0.011)	0.913	0.920 (0.033)	0.682 (0.039)	0.826
2000	0.964 (0.013)	0.901 (0.006)	0.904 (0.009)	0.842 (0.016)	0.918	0.851 (0.045)	0.754 (0.045)	0.868
2001	0.911 (0.007)	0.801 (0.010)	0.709 (0.008)	0.296 (0.010)	0.544	0.337 (0.025)	0.753 (0.063)	0.868
2002	0.895 (0.015)	0.882 (0.011)	0.882 (0.018)	0.652 (0.031)	0.807	0.844 (0.063)	0.612 (0.098)	0.782
2003	0.932 (0.015)	0.947 (0.005)	0.898 (0.012)	0.708 (0.018)	0.841	0.879 (0.032)	0.630 (0.066)	0.794
2004	0.948 (0.004)	0.860 (0.006)	0.820 (0.014)	0.519 (0.035)	0.720	0.465 (0.078)	NA	NA
2005	0.967 (0.004)	0.940 (0.004)	0.867 (0.009)	0.722 (0.023)	0.850	0.595 (0.040)	NA	NA
2006	0.920 (0.013)	0.956 (0.004)	0.911 (0.006)	0.808 (0.017)	0.899	0.795 (0.045)	0.813 (0.083)	0.902
2007	1.016 (0.026)	0.887 (0.009)	0.911 (0.022)	0.852 (0.030)	0.923	0.988 (0.098)	0.579 (0.059)	0.761
2008	0.995 (0.018)	0.935 (0.007)	0.961 (0.014)	0.776 (0.017)	0.881	0.950 (0.066)	0.742 (0.045)	0.861
2009	1.002 (0.011)	0.972 (0.005)	0.942 (0.008)	0.863 (0.014)	0.929	0.951 (0.026)	0.900 (0.079)	0.949
2010	1.017 (0.030)	0.965 (0.028)	0.984 (0.044)	0.876 (0.032)	0.936	0.931 (0.051)	0.840 (0.038)	0.917
2011	0.986 (0.017)	0.955 (0.004)	0.948 (0.010)	0.772 (0.014)	0.879	0.960 (0.043)	0.858 (0.051)	0.926
2012	1.001 (0.026)	0.959 (0.006)	0.914 (0.011)	0.811 (0.022)	0.901	0.814 (0.048)	1.021 (0.148)	1.010
2013[a]	0.973 (0.032)	0.921 (0.020)	0.977 (0.020)	0.739 (0.031)	0.860	0.799 (0.025)	1.026 (0.154)	1.013
Mean	**0.956 (0.009)**	**0.919 (0.010)**	**0.907 (0.014)**	**0.755 (0.032)**	**0.864**	**0.807 (0.046)**	**0.796 (0.038)**	**0.889**

a. Estimates are preliminary and subject to change.

Table 4. Hydropower system survival estimates derived by combining empirical survival estimates from various reaches for Snake River yearling **Chinook** salmon (hatchery and wild combined), 1997–2013. Standard errors in parentheses. Simple arithmetic means across all years are given. Abbreviations: Trap–Snake River Trap; LGR–Lower Granite Dam; MCN–McNary Dam; BON–Bonneville Dam.

Year	Trap–LGR	LGR-MCN	MCN-BON	LGR–BON	Trap–BON
1997	NA	0.653 (0.072)	NA	NA	NA
1998	0.924 (0.011)	0.770 (0.009)	NA	NA	NA
1999	0.940 (0.009)	0.792 (0.006)	0.704 (0.058)	0.557 (0.046)	0.524 (0.043)
2000	0.929 (0.014)	0.760 (0.012)	0.640 (0.122)	0.486 (0.093)	0.452 (0.087)
2001	0.954 (0.015)	0.556 (0.009)	0.501 (0.027)	0.279 (0.016)	0.266 (0.016)
2002	0.953 (0.022)	0.757 (0.009)	0.763 (0.079)	0.578 (0.060)	0.551 (0.059)
2003	0.993 (0.023)	0.731 (0.010)	0.728 (0.030)	0.532 (0.023)	0.528 (0.026)
2004	0.893 (0.009)	0.666 (0.011)	0.594 (0.074)	0.395 (0.050)	0.353 (0.045)
2005	0.919 (0.015)	0.732 (0.009)	0.788 (0.093)	0.577 (0.068)	0.530 (0.063)
2006	0.952 (0.011)	0.764 (0.007)	0.842 (0.021)	0.643 (0.017)	0.612 (0.018)
2007	0.943 (0.028)	0.783 (0.006)	0.763 (0.044)	0.597 (0.035)	0.563 (0.037)
2008	0.992 (0.018)	0.782 (0.011)	0.594 (0.066)	0.465 (0.052)	0.460 (0.052)
2009	0.958 (0.010)	0.787 (0.007)	0.705 (0.031)	0.555 (0.025)	0.531 (0.025)
2010	0.968 (0.040)	0.772 (0.012)	0.738 (0.039)	0.569 (0.032)	0.551 (0.038)
2011	0.943 (0.009)	0.746 (0.010)	0.687 (0.065)	0.513 (0.049)	0.483 (0.046)
2012	0.928 (0.012)	0.790 (0.016)	0.802 (0.051)	0.634 (0.042)	0.588 (0.040)
2013[a]	0.845 (0.031)	0.781 (0.016)	0.792 (0.071)	0.619 (0.057)	0.523 (0.052)
Mean	**0.940 (0.009)**	**0.742 (0.015)**	**0.709 (0.024)**	**0.533 (0.025)**	**0.501 (0.023)**

a. Estimates are preliminary and subject to change.

Table 5.   Hydropower system survival estimates derived by combining empirical survival estimates from various reaches for Snake River **steelhead** (hatchery and wild combined), 1997–2013. Standard errors in parentheses. Simple arithmetic means across all years are given. Abbreviations: Trap–Snake River Trap; LGR–Lower Granite Dam; MCN–McNary Dam; BON–Bonneville Dam.

Year	Trap–LGR	LGR-MCN	MCN-BON	LGR–BON	Trap–BON
1997	1.020 (0.023)	0.728 (0.053)	0.651 (0.082)	0.474 (0.069)	0.484 (0.072)
1998	0.924 (0.009)	0.649 (0.013)	0.770 (0.081)	0.500 (0.054)	0.462 (0.050)
1999	0.908 (0.011)	0.688 (0.010)	0.640 (0.024)	0.440 (0.018)	0.400 (0.017)
2000	0.964 (0.013)	0.679 (0.016)	0.580 (0.040)	0.393 (0.034)	0.379 (0.033)
2001	0.911 (0.007)	0.168 (0.006)	0.250 (0.016)	0.042 (0.003)	0.038 (0.003)
2002	0.895 (0.015)	0.536 (0.025)	0.488 (0.090)	0.262 (0.050)	0.234 (0.045)
2003	0.932 (0.015)	0.597 (0.013)	0.518 (0.015)	0.309 (0.011)	0.288 (0.012)
2004	0.948 (0.004)	0.379 (0.023)	NA	NA	NA
2005	0.967 (0.004)	0.593 (0.018)	NA	NA	NA
2006	0.920 (0.013)	0.702 (0.016)	0.648 (0.079)	0.455 (0.056)	0.418 (0.052)
2007	1.016 (0.026)	0.694 (0.020)	0.524 (0.064)	0.364 (0.045)	0.369 (0.047)
2008	0.995 (0.018)	0.716 (0.015)	0.671 (0.034)	0.480 (0.027)	0.478 (0.028)
2009	1.002 (0.011)	0.790 (0.013)	0.856 (0.074)	0.676 (0.059)	0.678 (0.060)
2010	1.017 (0.030)	0.770 (0.020)	0.789 (0.027)	0.608 (0.026)	0.618 (0.032)
2011	0.986 (0.017)	0.693 (0.013)	0.866 (0.038)	0.600 (0.029)	0.592 (0.030)
2012	1.001 (0.026)	0.698 (0.020)	0.856 (0.196)	0.597 (0.138)	0.598 (0.139)
2013[a]	0.973 (0.032)	0.645 (0.026)	0.798 (0.112)	0.515 (0.075)	0.501 (0.075)
Mean	**0.963 (0.010)**	**0.631 (0.037)**	**0.660 (0.044)**	**0.448 (0.041)**	**0.436 (0.043)**

a. Estimates are preliminary and subject to change.

Table 6. Estimated survival and standard error (s.e.) through reaches of the lower Columbia River hydropower system for hatchery yearling **Chinook** salmon and **steelhead** originating in the upper Columbia River, 1999–2013. Abbreviations: Rel–Release site; MCN–McNary Dam; JDA–John Day Dam; BON–Bonneville Dam.

Year	Yearling Chinook Salmon				Steelhead			
	Rel–MCN	MCN-JDA	JDA-BON	MCN–BON	Rel–MCN	MCN-JDA	JDA-BON	MCN–BON
1999	0.572 (0.014)	0.896 (0.044)	0.795 (0.129)	0.712 (0.113)				
2000	0.539 (0.025)	0.781 (0.094)	NA	NA				
2001	0.428 (0.009)	0.881 (0.062)	NA	NA				
2002	0.555 (0.003)	0.870 (0.011)	0.940 (0.048)	0.817 (0.041)				
2003	0.625 (0.003)	0.900 (0.008)	0.977 (0.035)	0.879 (0.031)	0.471 (0.004)	0.997 (0.012)	0.874 (0.036)	0.871 (0.036)
2004	0.507 (0.005)	0.812 (0.019)	0.761 (0.049)	0.618 (0.038)	0.384 (0.005)	0.794 (0.021)	1.037 (0.112)	0.823 (0.088)
2005	0.545 (0.012)	0.751 (0.042)	NA	NA	0.399 (0.004)	0.815 (0.017)	0.827 (0.071)	0.674 (0.057)
2006	0.520 (0.011)	0.954 (0.051)	0.914 (0.211)	0.871 (0.198)	0.397 (0.008)	0.797 (0.026)	0.920 (0.169)	0.733 (0.134)
2007	0.584 (0.009)	0.895 (0.028)	0.816 (0.091)	0.730 (0.080)	0.426 (0.016)	0.944 (0.064)	0.622 (0.068)	0.587 (0.059)
2008	0.582 (0.019)	1.200 (0.085)	0.522 (0.114)	0.626 (0.133)	0.438 (0.015)	NA	NA	NA
2009	0.523 (0.013)	0.847 (0.044)	1.056 (0.143)	0.895 (0.116)	0.484 (0.018)	0.809 (0.048)	0.935 (0.133)	0.756 (0.105)
2010	0.660 (0.014)	0.924 (0.040)	0.796 (0.046)	0.735 (0.037)	0.512 (0.017)	0.996 (0.054)	0.628 (0.038)	0.626 (0.033)
2011	0.534 (0.010)	1.042 (0.047)	0.612 (0.077)	0.637 (0.077)	0.435 (0.012)	1.201 (0.064)	0.542 (0.101)	0.651 (0.119)
2012	0.576 (0.012)	0.836 (0.035)	1.140 (0.142)	0.953 (0.115)	0.281 (0.011)	0.862 (0.047)	1.240 (0.186)	1.069 (0.159)
2013[a]	0.555 (0.013)	0.965 (0.050)	1.095 (0.129)	1.056 (0.117)	0.384 (0.020)	0.957 (0.071)	0.974 (0.104)	0.932 (0.099)
Mean	**0.554 (0.014)**	**0.904 (0.028)**	**0.869 (0.054)**	**0.794 (0.040)**	**0.419 (0.020)**	**0.917 (0.041)**	**0.860 (0.068)**	**0.772 (0.048)**

a. Estimates are preliminary and subject to change.

Table 7. Estimated survival and standard error (s.e.) for **sockeye** salmon (hatchery and wild combined) from Lower Granite Dam tailrace to Bonneville Dam tailrace for fish originating in the Snake River, and from Rock Island Dam tailrace to Bonneville Dam tailrace for fish originating in the upper Columbia River, 1996–2013. Note that this table represents all available data on sockeye, and so estimates are provided regardless of the size of their associated standard errors. The estimates to Bonneville tailrace are of questionable quality in several cases due to small release sizes and low detection probabilities. Abbreviations: LGR–Lower Granite Dam; MCN–McNary Dam; BON–Bonneville Dam; RIS–Rock Island Dam.

Year	Snake River Sockeye			Upper Columbia River Sockeye		
	LGR-MCN	MCN-BON	LGR-BON	RIS-MCN	MCN-BON	RIS-BON
1996	0.283 (0.184)	NA	NA	NA	NA	NA
1997	NA	NA	NA	0.397 (0.119)	NA	NA
1998	0.689 (0.157)	0.142 (0.099)	0.177 (0.090)	0.624 (0.058)	1.655 (1.617)	1.033 (1.003)
1999	0.655 (0.083)	0.841 (0.584)	0.548 (0.363)	0.559 (0.029)	0.683 (0.177)	0.382 (0.097)
2000	0.679 (0.110)	0.206 (0.110)	0.161 (0.080)	0.487 (0.114)	0.894 (0.867)	0.435 (0.410)
2001	0.205 (0.063)	0.105 (0.050)	0.022 (0.005)	0.657 (0.117)	NA	NA
2002	0.524 (0.062)	0.684 (0.432)	0.342 (0.212)	0.531 (0.044)	0.286 (0.110)	0.152 (0.057)
2003	0.669 (0.054)	0.551 (0.144)	0.405 (0.098)	NA	NA	NA
2004	0.741 (0.254)	NA	NA	0.648 (0.114)	1.246 (1.218)	0.808 (0.777)
2005	0.388 (0.078)	NA	NA	0.720 (0.140)	0.226 (0.209)	0.163 (0.147)
2006	0.630 (0.083)	1.113 (0.652)	0.820 (0.454)	0.793 (0.062)	0.767 (0.243)	0.608 (0.187)
2007	0.679 (0.066)	0.259 (0.084)	0.272 (0.073)	0.625 (0.046)	0.642 (0.296)	0.401 (0.183)
2008	0.763 (0.103)	0.544 (0.262)	0.404 (0.179)	0.644 (0.094)	0.679 (0.363)	0.437 (0.225)
2009	0.749 (0.032)	0.765 (0.101)	0.573 (0.073)	0.853 (0.076)	0.958 (0.405)	0.817 (0.338)
2010	0.723 (0.039)	0.752 (0.098)	0.544 (0.077)	0.778 (0.063)	0.627 (0.152)	0.488 (0.111)
2011	0.659 (0.033)	NA	NA	0.742 (0.088)	0.691 (0.676)	0.513 (0.498)
2012	0.762 (0.032)	0.619 (0.084)	0.472 (0.062)	0.945 (0.085)	0.840 (0.405)	0.794 (0.376)
2013[a]	0.691 (0.043)	0.776 (0.106)	0.536 (0.066)	0.741 (0.068)	0.658 (0.217)	0.487 (0.155)
Mean	**0.617 (0.041)**	**0.566 (0.085)**	**0.406 (0.059)**	**0.671 (0.035)**	**0.775 (0.096)**	**0.537 (0.067)**

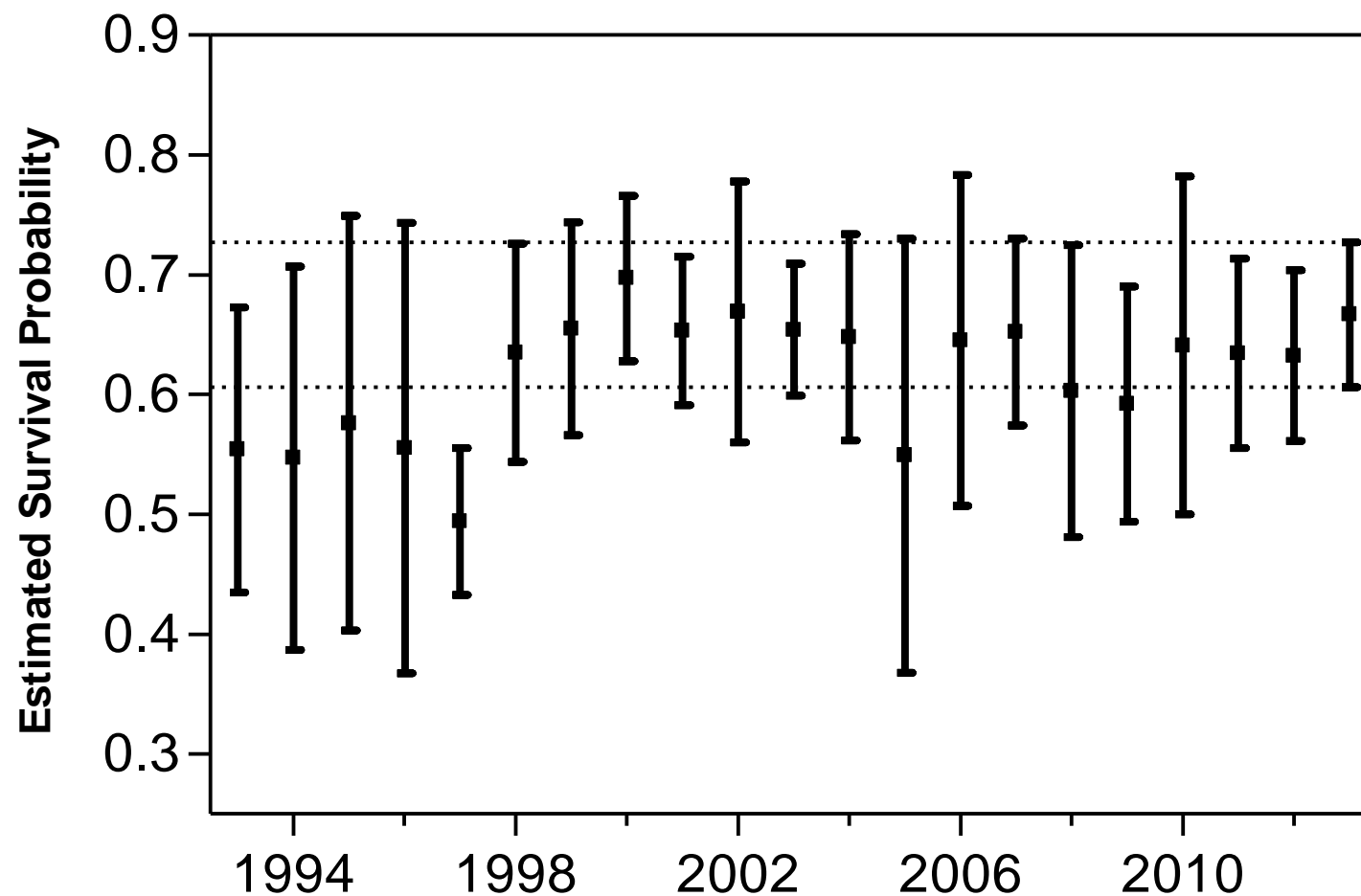a. Estimates are preliminary and subject to change.

Figure 1. Annual average survival estimates from release to Lower Granite Dam for PIT-tagged yearling **Chinook** salmon released from Snake River Basin hatcheries, 1993-2013. Hatcheries used for average (index groups) are those with PIT-tag releases through a long series of years. Vertical bars represent 95% confidence intervals. Horizontal dashed lines are the 2013 confidence interval endpoints and are shown for comparison to other years.
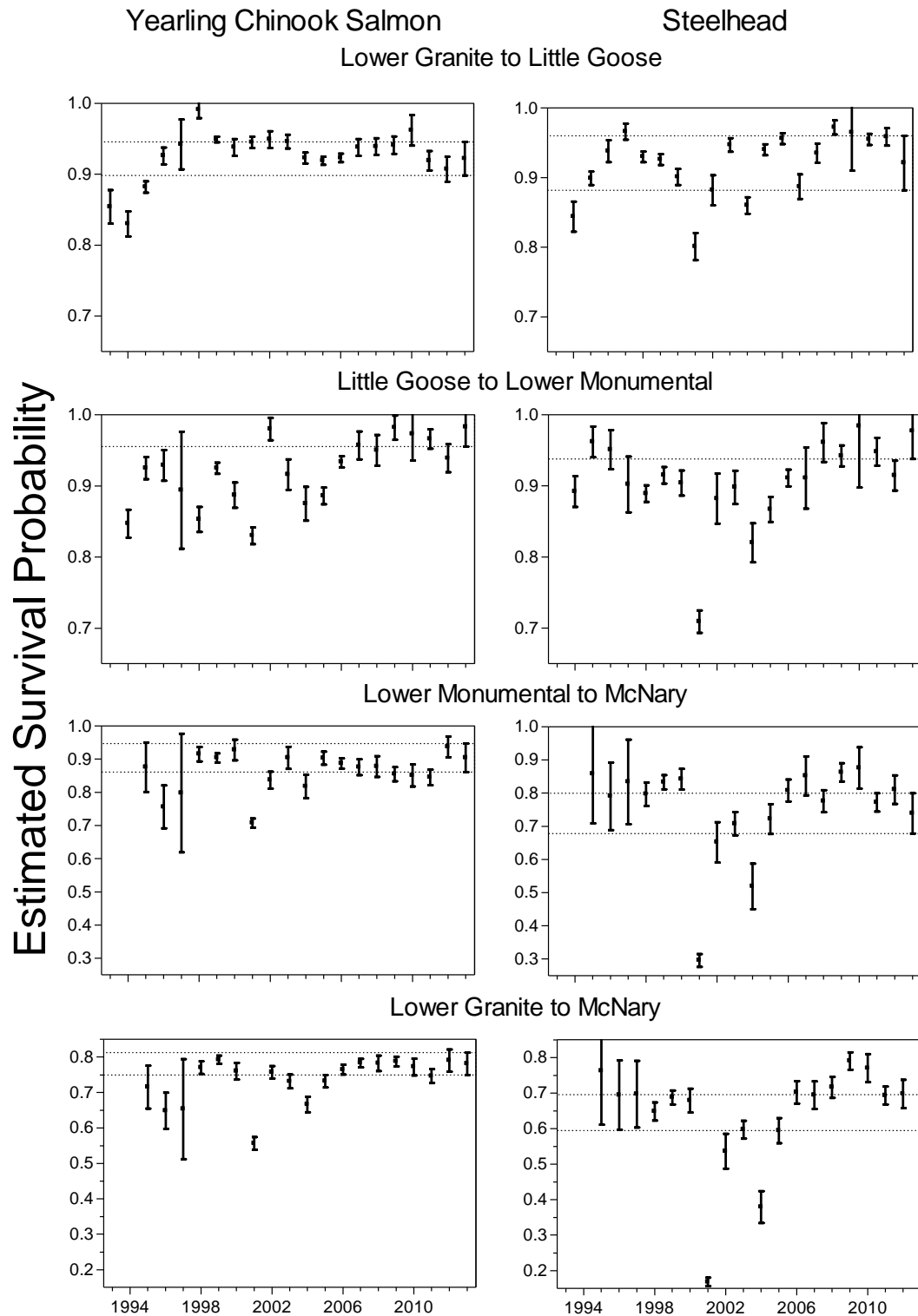
Figure 2. Annual average survival estimates for PIT-tagged yearling **Chinook** salmon and **steelhead**, hatchery and wild fish combined. Vertical bars represent 95% confidence intervals. Horizontal dashed lines are 95% confidence interval endpoints for 2013 estimates.
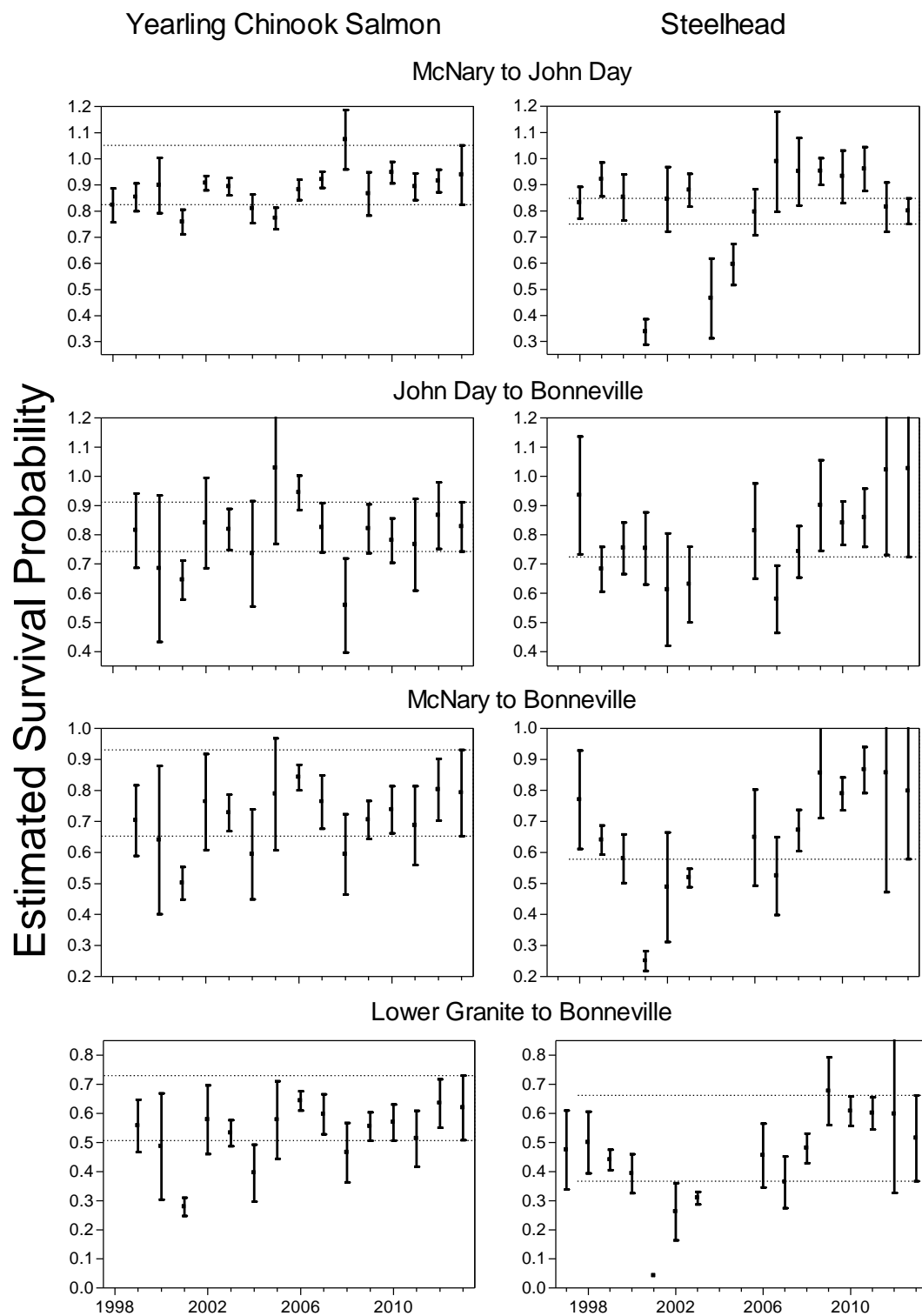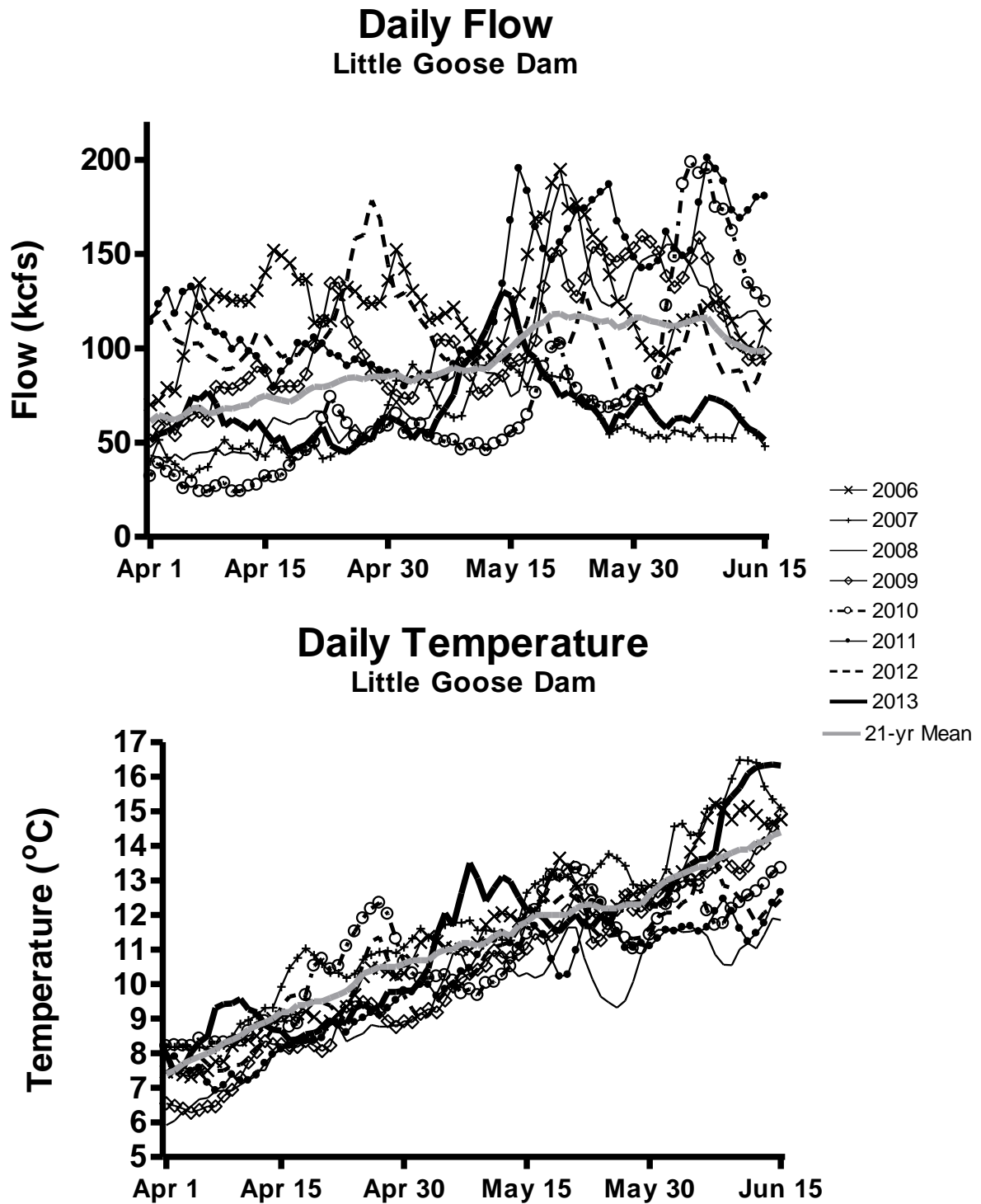
Figure 3. Annual average survival estimates for PIT-tagged yearling **Chinook** salmon and **steelhead**, hatchery and wild fish combined. Vertical bars represent 95% confidence intervals. Horizontal dashed lines are 95% confidence interval endpoints for 2013 estimates.

Daily Flow
Little Goose Dam

Daily Temperature
Little Goose Dam

Figure 4. Snake River flow (kcfs; top panel) and water temperature (^{o}C; bottom panel) measured at Little Goose Dam during April and May, 2006-2013, including daily long-term means (1993-2013).
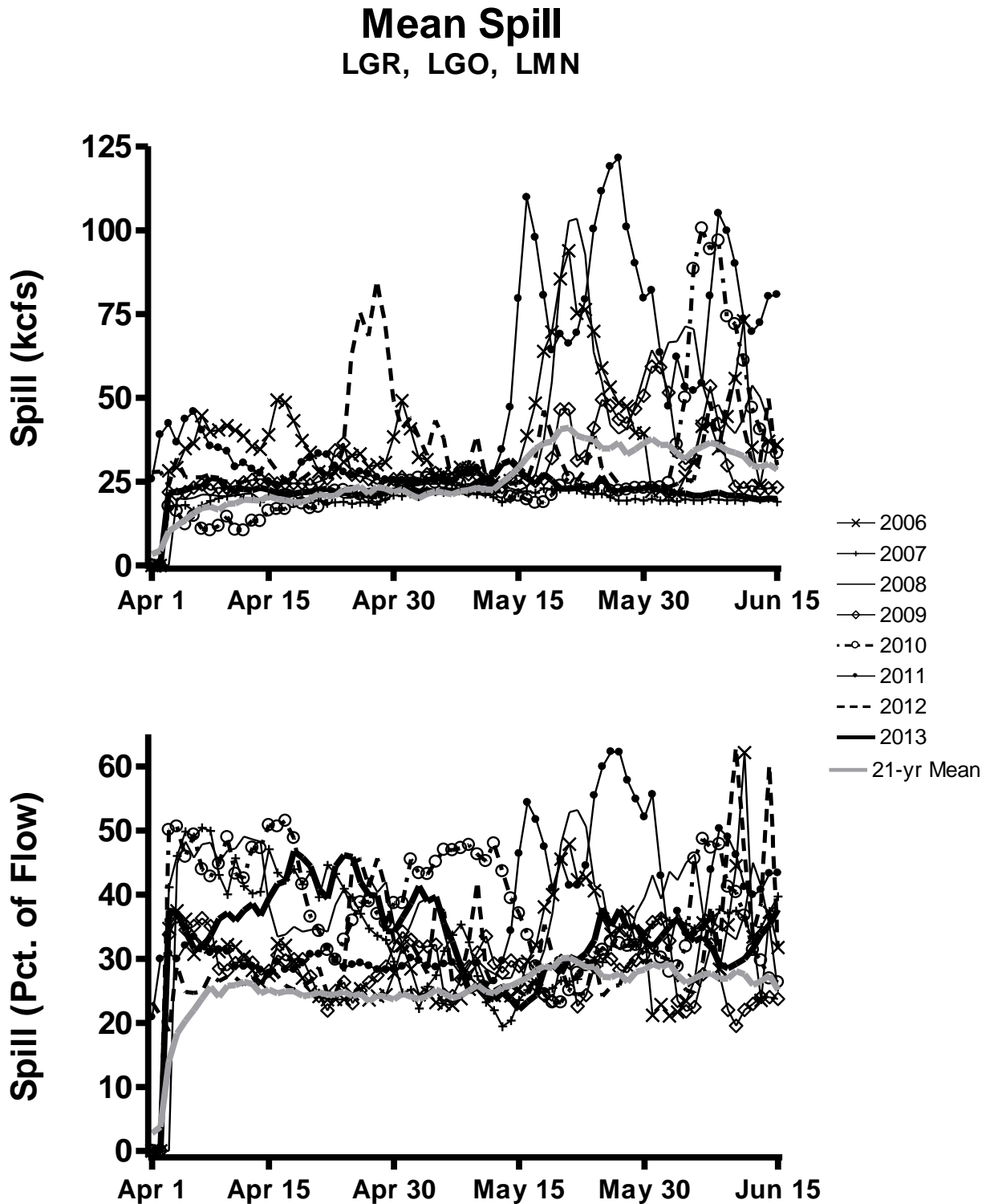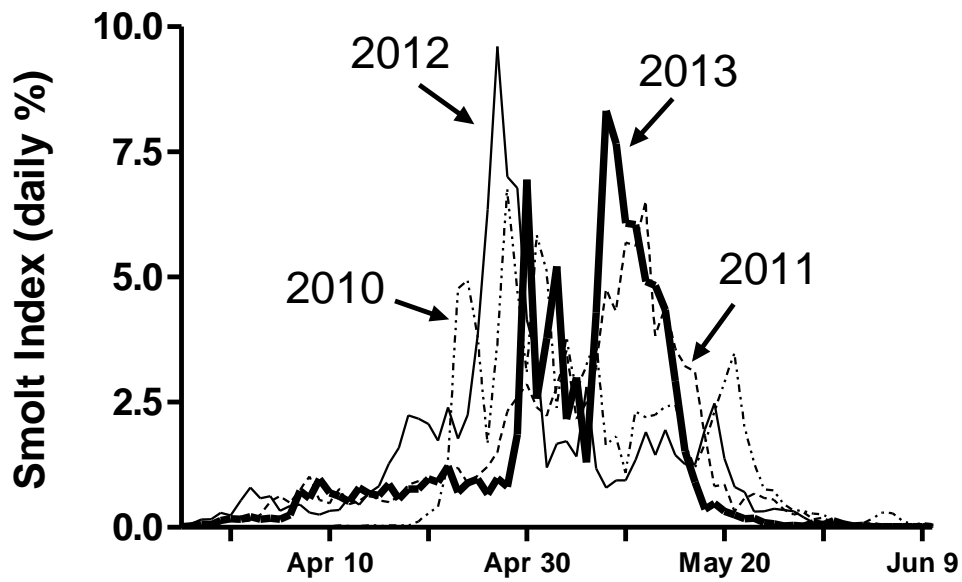
Mean Spill

LGR, LGO, LMN

Figure 5. Mean spill (top panel shows kcfs; bottom panel shows percentage of total flow) at Snake River dams during April and May, 2006-2013, including daily long-term means (1993-2013).

Smolt Passage at Lower Granite Dam

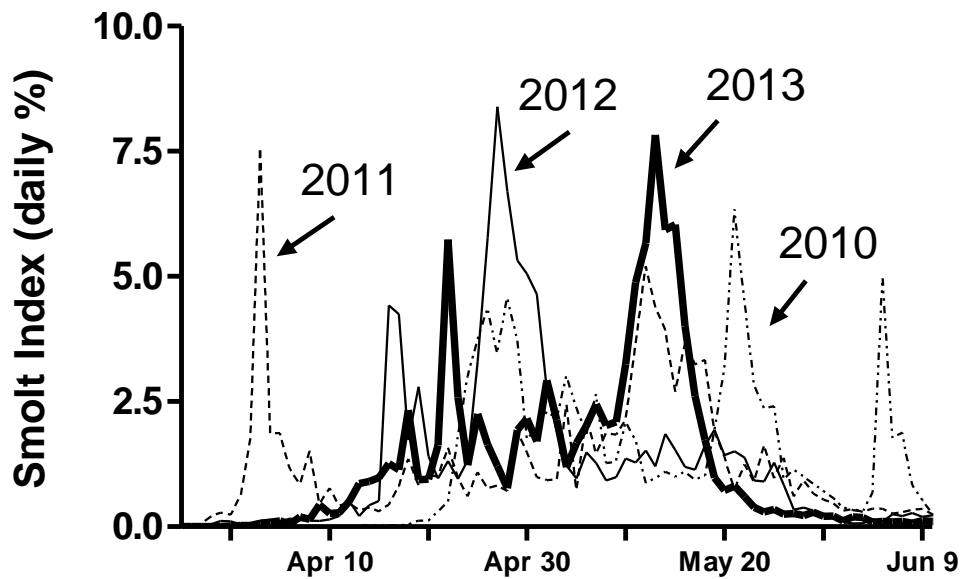## Yearling Chinook

Steelhead

Figure 6. Smolt index as daily percentage of total passage at Lower Granite Dam 2010-2013 for hatchery and wild combined yearling Chinook and steelhead.